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MANUAL ON DDT INSECTICIDE

Bureau of Medicine and Surgery
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Washington, D.C.
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Prepared by

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DDT is comparatively new and the methods of application are still somewhat in the experimental stage, but production has now reached a point permitting its use in the field. This manual contains data and recommendations which are based upon the best information available at the present time. It is anticipated that the subject matter contained herein will require revision at a later date.

CONTENTS

I. Introduction.

DDT was first synthesized by a Germ an chemist in 1874, but its insecticidal properties were not discovered until 1939, when a Swiss chemical firm (J. R. Geigy, Inc.) began to use it in the control of moths and plant lice. The U. S. Department of Agriculture tested a sample in November 1942, and found it to be effective against nearly all insects. During 1943 and the first six months of 1944, that Department conducted extensive experiments to determine how DDT could best be used against the insects which threaten the health, morale and military efficiency of our troops. During this period DDT was available only in quantities for experimentation. The large scale manufacture of this substance has been achieved during time of war only through the high priorities accorded it by the War Production Board, the Army and the Navy.

In 1943, when the Department of Agriculture laboratory at Orlando, Fla., was sending its first reports on DDT to the Army and the Navy, many of the accounts were difficult to believe. There was a report of a duck swimming in a pond which had been treated with DDT for larvicidal action. The duck waddled over to a large puddle and resumed his swimming. All the larvae in the second puddle were later found to be killed. A cage full of experimental flies were unintentionally killed when DDT dust was mixed at a great distance from the cage. Laboratory technicians having traces of DDT on their hands have ruined experiments when they picked up small cages in which experimental insects were kept; all the insects were killed. It was reported that one (1) part DDT in 20,000,000 parts of water killed 100 percent of larvae; one (1) part DDT in 100,000,000 parts of water killed 40.7 percent of larvae.

As reports continued to come in, it was realized that DDT could accomplish all the feats ascribed to it, and many more. The prolonged residual effectiveness of DDT against insects constitutes its main advantage over previously used insecticides. In addition, minute doses are adequate for lethal action on most insects. When suitable precautions are taken, the recommended doses are not harmful to humans. Ingestion of DDT by insects is not required; absorption takes place from the surface of the insect's body and extremities.

The use of DDT requires special knowledge and training. This manual is intended to serve as a technical guide to the efficient, safe and economical use of DDT.

II. Synonyms:

"Gesarol", "Neocide", SBLY.

III. Chemical and Physical Characteristics.

Chemical Names:

2-2 Bis(p-chlorophenyl) 1-1-1 trichloroethane.
Dichloro-diphenyl-trichloroethane.

In the commercially pure form procured by the Armed Services, DDT is a fine white powder. In the unadulterated state there is a tendency for the particles to lump. This tendency to lump is present in dusts having a DDT content greater than 10 percent. DDT does not deteriorate when exposed to atmosphere and sunlight, and does not evaporate. The residue on a sprayed surface retains its effectiveness as a contact poison for several weeks. It is not destroyed by temperatures encountered in ordinary storage on board ship or in the tropics. The physical properties of DDT are such that it may be dispersed either in oil solutions, in emulsions, or in diluted dusts.

DDT is insoluble in water. Its solubility in some of the more common organic solvents is as follows (on the basis of weight of DDT and volume of solvent):

Cyclohexanone	-	100 to 120 gms. per 100cc.
Xylene	-	56 gms. per 100 cc.
Dimethylphthalate	-	31 gms. per 100 cc.
Indalone	-	29 gms. per 100 cc.
Ether	-	27 gms. per 100 cc.
Triton	-	20 gms. per 100 cc.
Tung Oil	-	10 -14 gms. per 100 cc.
Sesame Oil	-	10 gms. per 100 cc.
Fuel Oil #2	-	10 gms. per 100 cc.
Kerosine (Crude)	-	5 to 8 gms. per 100 cc.
Kerosine (Purified)	-	2 to 4 gms. per 100 cc.
Freon (12)	-	2 gms. per 100 cc.
Ethyl alcohol	-	1 .5 gms. per 100 cc.

IV. Physiologic Effect on Insects.

Powerful action on the insect nervous system results from the absorption of DDT through the chemotactic sensorial organs in the tips of the tarsi. A short time after exposure insects drag their legs, movements become poorly coordinated and they finally develop tremors and convulsions prior to death. DDT does not repel insects, but after obtaining a lethal dosage, either from the air or from residual particles of DDT on surfaces, they become restless and attempt to escape, dying elsewhere. For this reason, it is possible that dead insects may not be found in treated areas. In experiments all insects trapped in the act of escaping from treated areas died

within 2 to 12 hours.

V. Toxicity to Humans.

On the basis of effective insecticidal dosage DDT is definitely less toxic than Paris green, sodium fluoride, lethane and thanite.

A. Action on the Skin: Animal experiments have shown that there is no absorption of the dry powder from the skin, but concentrated oily solutions are absorbed, large doses causing hyperexcitability, tremors, clonic convulsions and liver damage. Therefore, men engaged in mixing or spraying the oily solutions of DDT should take all precautions to prevent the material from spilling on or coming in contact with the skin. Occasional contact is apparently not dangerous; repeated or prolonged contact must be avoided. For this reason the decontamination type of sprayer is preferable to the knapsack type; if the knapsack sprayer is used, it should be only half filled to avoid spilling.

B. Parenteral Absorption: In animals, dry DDT is not readily absorbed when injected intramuscularly or subcutaneously. In oils, however, it acts in the same manner as when absorbed in oily solution from the skin.

C. Effect on the Respiratory Tract: No toxic symptoms occurred in dogs and rats when exposed in an atmosphere containing many times the recommended insecticidal concentration of DDT in aerosol. Daily exposure of monkeys and men for one hour to heavy concentrations of DDT in dust caused no ill effects. The toxicity from the inhalation of heavy concentrations of DDT smokes has not been definitely determined, but probably is no greater than that of similar exposure to sprays or aerosols.

D. Effect on the Gastro-intestinal Tract: In animals, 100 mgs. of DDT per kilo per day (by mouth) produced no toxic effects. Two hundred (200) mgs. per kilo per day killed 90 percent of the test animals; they showed tremors, convulsions, incoordination, prolonged prothrombin time, toxic necrosis of the liver, and a terminal nephritic picture. This is many times the amount an individual would obtain when exposed to the recommended doses of DDT. The occasional ingestion of water which has been treated for larvicidal action is apparently not harmful, but this practice must be avoided wherever possible.

E. Cyclohexanone (which is frequently used as a solvent for DDT) is less than one-tenth as toxic as DDT. In heavy concentration it produces a harmless temporary irritation to the eyes, nose and

lungs. In extremely heavy dosage it possesses a depressant action on the central nervous system.

F. Conclusions: In galleys DDT should only be used under those conditions which exclude the massive contamination of food. Foods and cooking utensils should be thoroughly covered when DDT is being disseminated. DDT is tasteless and bears a physical resemblance to flour; therefore, it must not be stored alongside food supplies. Although oily solutions are absorbed from the skin, a 5 percent solution may be safely used if reasonable precautions are taken to prevent contact. Other non-volatile solvents, such as repellents, may also act as vehicles from which absorption of DDT powder through the skin is possible. Therefore DDT powder must not be applied to areas of the skin on which repellents are to be applied. The 10 percent powder (or dust) is safe; personnel engaged in mixing dusts should wear a respirator or a moist cloth over the nose and mouth during the mixing process. This is not necessary, however, when dispensing the dust if care is taken to disperse it to the leeward.

VI. Forms in Which Supplied by the Navy.

Items A, B, and C are procured by the Bureau of Supplies and Accounts under BuShips Stock No. 51-1 -(new). Item D is procured by the Bureau of Medicine and Surgery.

A. Insecticide Concentrate Powder (DDT) (commercially pure DDT) is supplied in 5 pound (Standard Stock Catalog Number 51-I-157-5) and 25 pound (Standard Stock Catalog Number 51-1-157-25) airtight cans. In the field this powder is used for making up the 5 percent oil or kerosene solutions; the emulsion may be made in the field if the other ingredients are available (see below).

B. Insecticide Concentrate Solution (DDT-xylene-emulsifying agent) is supplied in one-gallon and five-gallon drums (Standard Stock Catalog Number 51-I-157-500). The formula under which procurement probably will be made consists of 25 percent DDT, 68 percent xylene (solvent), and 7 percent Triton x-l00 (emulsifier). This is the concentrated stock solution from which the water emulsion is prepared.

C. Insecticide Diluted Powder (10 percent DDT) (10 percent DDT in talc or pyrophyllite) is supplied in five-and ten-pound cans for use against larvae, roaches, flies, etc. This material has a very limited field of use.

D. Insecticide Powder (for Body Lice) (NavMed Supply Catalog, Stock No. Fl3-451) is supplied in a two-ounce can for use as

louse powder. This is 10 percent DDT in talc or pyrophyllite. The same powder will likewise be available in five-pound cans as a BuMed item for use in treating large groups of individuals when mass dusting programs are indicated.

VII. Forms in Which Dispersed.

The amount of DDT applied is the important factor in DDT dosage rather than the total amount of mixture. The amount of diluent is important only in that it insures even distribution of the active ingredient. For instance, one quart of 5 percent DDT in oil contains the recommended larvicidal dosage per acre (0.1 pound of DDT). On water surfaces where dense vegetation or strong winds interfere with uniform surface coverage, it is more expedient to use five quarts of 1 percent solution. Likewise, it is difficult to properly spread one pound of 10 percent dust over an acre surface, but ten pounds of 1 percent dust may be evenly distributed over such an area.

A. Solutions will be widely used due to the fact that oil and kerosene are available in almost all theaters of operation. In larval control the use of DDT requires a much smaller amount of oil, as well as giving longer control than is experienced with other larvicides. DDT goes into solution in oils rather slowly, requiring 12 to 24 hours. By occasional stirring and placing the oil in the sun, the heat will hasten the process. Two and one-fourth pounds of DDT in five gallons of oil yields a 5 percent solution. (Based on weight/volume--DDT/oil.)

(1) Diesel oil #2 gives the best results, having a viscosity well suited to the sprayers now in use. It will dissolve 10 grams of DDT per 100 cubic centimeters.

(2) Lubricating oil #10 and crank-case oil are slightly less desirable than Diesel oil. They should be thinned by the addition of kerosene if a fine or semi-fine spray is needed.

(3) Kerosene (crude) will dissolve 5 to 8 grams of DDT per 100 cubic centimeters. Purified kerosene will dissolve only 2 to 4 grams per 100 cubic centimeters. These solutions are well adapted for use as a fine fog-like spray against adult insects; they are also recommended for uses where darker oil stains are to be avoided, as in galleys, for residual effect on walls, and on mattresses (bedbug control).

(4) Fortified oil solutions, in which the solubility of DDT is increased by the addition of cyclohexanone, or other solvents, to the oil, may be recommended at a later date for certain limited uses (as in combat areas where oil is difficult to transport, and in spraying from planes).

B. Emulsion is the form of choice when a prolonged residual effect is desired, as in galleys, in planes, in living quarters, and in the impregnation of clothing. The increased amount of shipping involved in the use of the Emulsion Concentrate, as well as the limited supply of its ingredients, require that it must not be used in situations where oil solutions may be employed. The concentrated "stock" solution (as shipped) may be kept indefinitely if the container is kept tightly closed. Before being used, it should be diluted with four (4) parts of water (making a 5 percent emulsion) and thoroughly stirred. Any clean water, including rain or river water, sea water, brackish water or "hard water" may be employed in the preparation of the emulsion. When brackish water or sea water is used, sprayers must be thoroughly rinsed or oiled after use to prevent corrosion of the metal parts. On standing, after dilution with water, a creamy layer may form at the surface, indicative of a breaking of the emulsion; this in no way affects its action, and only requires that the emulsion be thoroughly stirred before it is poured into the sprayers for use. If the ingredients are available and the emulsion concentrate is desired, it may be prepared as follows: Dissolve three and one-half parts (by weight) in 9 parts of xylene (by weight), then stir in 1 part (by weight) of Triton X-100. The mixture is then ready for dilution with water.

C. Dust (10 percent DDT in talc or pyrophyllite) has the following disadvantages: (1) Requires shipping of 90 percent diluent. (2) Extreme susceptibility to wind. (3) Tendency of particles of DDT to lump together into large inert particles. When used, it may be distributed by the Freeney, Hudson, Dobbins or other type of equipment dispensing a fine dust. Either the plunger or rotary type duster may be employed. The 10 percent dust has been found to be most effective against body lice; it is also effective against cockroaches. There is some evidence indicating that in strengths of 1 percent to 5 percent, the dust may have some effect against other adult insects. In strengths of 1 percent to 5 percent it may be used as a larvicide. For diluting the 10 percent dust (as issued), condemned flour, fine road dust, soapstone, etc., may be used; thorough mechanical mixing is required. The concentrated DDT powder (100 percent) must not be diluted in the field for use as a dust due to the fact that the required small size of the particles cannot be produced without heavy grinding equipment.

D. Smokes containing DDT have been given field tests. Various smoke generators have been tried, including machines in which DDT-oil solutions have been injected into combustion chambers and into heated coils. Mechanical difficulties, meterologic factors, and problems of DDT particle size in smokes must be overcome before this method of dispersal can be recommended.

E. Aerosol Bombs. Bombs in use at the present time do not contain DDT, and thus have practically no effect on flies and other insects except mosquitoes. It is intended for use solely against mosquitoes. Experimental aerosols containing 0.3 percent pyrethrins with 3 percent DDT have been shown to be a nearly perfect all-purpose insecticide. The aerosol dispersal is too fine for use as a residual DDT

spray. The use of DDT in aerosol bombs is expected to play a prominent role in the disinsectization of planes and in the reduction in the incidence of dysentery, malaria, dengue filariasis, and other insect borne diseases. Certain mechanical difficulties have so far prevented. the general use of DDT in aerosol bombs. When these difficulties are overcome DDT will be added to the aerosol formula.

VIII. Special Features of Application.

The present recommended methods of use (see IX below) are based upon experiments in which equipment available in the field was utilized. There are certain special points worth noting:

A. Nozzles

1. For use against adult insects the best results are obtained with a nozzle producing a very fine, fog-like spray. The whirler-type nozzle having a very small hole in the disk is well adapted for this use. This hole should be of 56 gage or smaller (60 gage is best). These gages represent a nozzle opening of about 3/64 inch. The double-head nozzle with which the decontamination sprayer is equipped is absolutely unsatisfactory.

2. For larviciding a fine spray is required, but if too fine the material will be blown away and thereby wasted. The disks now available in the field may be used for this purpose.

3. For Residual Effect on Solid Surfaces a semi-fine spray is needed, producing a moist (not soaking wet) surface. The nozzle should be held 4 to 8 inches from the surface which is being treated. Application should be made so as to leave 0.1 to 0.2 gram of DDT per square foot (2.0 to 4.0 cc. of a 5 percent solution or emulsion). At these rates one quart is adequate for 250 to 500 square feet of surface. The residual DDT will continue to kill insects which alight on the treated surface for many weeks or months (depending on weathering, rain, washing, etc.). The emulsion is best suited for this use, especially on surfaces where staining by oil would be objectionable. Kerosene and oils having a low viscosity give almost as good results. The surfaces on which insects are prone to alight should be treated in this manner, such as screens, rafters, dark corners, light cords, the inside canvas of tents, ceilings, cracks, etc. In the open spaces vegetation, tree trunks, heads, etc., may be treated. DDT solutions and emulsions are most economically applied to screening, light cords, etc., by means of paint brushes.

B. Sprayers. Both the knapsack and the decontamination sprayers develop pressures adequate for dispersing DDT. With the same pressure and nozzle size the emulsion and kerosene solutions will be delivered at a rate of 25 percent to 35 percent slower than the rate of delivery for the oil solutions. The knapsack sprayer tends to spill oil on the skin of the operator; for that reason it should be only half filled. Hand sprayers of the "Flit-gun" type may be used in small scale work. Paint sprayers (hand or power operated), when available, give excellent results. Sprayers in which xylene emulsions are used are subject to more rapid rust and corrosion than those in which oils are used. This should be guarded against by washing out and filling sprayer with water following use. If sprayer is not to be used for several days, it should be dried out and oiled. Ordinary rubber washers, gaskets and tubing deteriorate rapidly in contact with oils and other solvents. Therefore oil-resistant fittings must be employed.

C. Dusters. Any dispenser which produces a fine dust may be utilized. (See under "Dust", VII - C).

D. Aeroplane Dissemination. Solutions, dusts and smokes have been experimentally dispersed from aeroplanes. Only the solutions have reached a point where they may be recommended. Special multinozzle sprayers of 25-gallon capacity are being developed for use on small planes of the Cub type. The Army M-l0 tank (27-gallon capacity), and the Navy M-5 tank (45-gallon capacity) have given fairly satisfactory results from speedy planes. One to two quarts of 5 percent solution are required per acre for larval control; up to four quarts may be required for control of adult insects. Area control during critical military operations is envisioned by this means. Further instructions will be issued after experimentation is completed.

IX. Meteorologic and Other Conditions Affecting the Use of DDT.

A. Rain. Although DDT tends to stick to surfaces, a considerable amount is washed away by repeated or heavy rains. Small bodies of water have been found to contain larvicidal concentrations as a result of DDT being washed into them from vegetation and other surfaces. The overflow of nonflowing bodies of water decreases the DDT content, requiring more frequent application.

B. Wind. If favorable winds of low velocity prevail fine sprays,, dusts, aerosols, and smokes may be drifted by the wind through. an area; this is particularly helpful in treating inaccessible jungle areas and water surfaces. In this manner, adult insects are killed in the air, and larvicidal action may be obtained after the material falls to the water surface. Excessive winds may blow the material out of the control area; for that reason it may be desirable to

distribute DDT during the windless portion of the day. Dusts and smokes are particularly susceptible to very slight wind currents. Dusts and emulsions are blown aside on water surfaces to a lesser extent than is the case with oily solutions of DDT.

C. Temperatures. Heat currents from the hot ground may carry fine sprays, dust and smoke skyward, requiring application in the cool of the morning. Most insects appear to be susceptible to smaller doses of DDT in cool weather.

D. Vegetation tends to protect larvicidal material, preventing the wind from disrupting the uniform surface coverage. Sprays from aeroplanes penetrate dense jungle undergrowth better than one would expect. DDT deposited on vegetation possesses residual action against insects. Sprays, dusts and smokes will kill larvae breeding in water collections of certain trees, as bromeliads, coconut fronds, screw (Pandanus) palms, etc.

E. Washing. Bulkheads, screens, and other surfaces treated with liquid or dust forms of DDT for residual effect should not be washed unless absolutely necessary. Surfaces washed or repeatedly wet will require more frequent application of DDT.

X. Recommendations for Use of DDT.

One of the outstanding advantages of DDT over other insecticides is its versatile action against nearly all insects. Effectiveness is of a high order against adult mosquitoes and mosquito larvae, flies, bedbugs, lice, and roaches.

A. Against Adult Mosquitoes.

1. 5 percent DDT in kerosene, light oil or emulsion, when sprayed as a mist at a rate of one quart per acre, has given 90 per cent to 99 percent control within one hour. Unless a large surrounding area is treated in this manner, mosquitoes will infiltrate the treated area. In some experiments areas have been kept free of mosquitoes for several days. The variables of sprayer pressure, nozzle size and ventilation prevent specific dosage recommendation for spraying in closed spaces. Relatively small amounts are adequate; these minimum amounts must be determined by the individual.

2. Dust. Area treatment with dust has been tried, but the results have been erratic and, in general, inferior to treatment with sprays. When used, the recommended dosage is

one in which 0.1 to 0.5 pounds of the pure DDT is applied per acre. Under adverse conditions, such as heavy vegetation and strong wind, twice this dosage may be required.

3. Aerosol Bomb. The contents of a single one pound aerosol bomb, containing 5 percent DDT, has been shown to control 95 percent of the mosquitoes in an area equivalent to one acre for several hours, the material being distributed in 20 foot swaths. In other experiments where conditions were modified by heavy vegetation, strong winds, and the influx of mosquitoes from surrounding areas, results were much poorer.

4. Residual Effect (See VIII, A, 3). A barn in Arkansas was treated with .022 gram of DDT (in 5 percent kerosene solution) per square foot. Hundreds of dead mosquitoes were found after the first night, over 50,000 were found after the second night; it is not known how many flew out the open doors and died elsewhere. All of those trapped in the act of escaping died in less than 24 hours. Heavier application (0.1 to 0.2 gram per square foot) gives residual lethal effect persisting for weeks. Experiments indicate that the emulsion is equally effective. The residual effect with dusts is less pronounced. Aerosols, due to their fine dispersal, possess minimal effectiveness.

B. Against Mosquito Larvae.

1. Unlike Paris green, DDT is effective against Culicine larvae, as well as Anopheline larvae. Five percent DDT in kerosene or oil (Diesel, lubricating or crankcase) will be most widely used in the field. Oil, when used alone, is required in amounts of 10 to 15 gallons per acre; the 5 percent DDT solution, in amounts of 1 to 2 quarts per acre, is usually adequate for 6 to 9 days control. Higher doses may be necessary, depending upon overflow, rain and vegetation. These variables make weekly larval counts necessary as a check on effectiveness. Prolonged effectiveness up to 3 to 4 weeks may be obtained with doses containing 0.5 to 1.0 pound of DDT per acre (5 to10 quarts of the 5 percent solution). Except in combat or other critical situations these heavy doses are wasteful and unwarranted. DDT does not increase the spreading properties of oil. Best results are obtained through applying the oil as a fine (not fog-like) spray, utilizing wind drift for reaching inaccessible water surfaces. Results are much poorer when solutions are poured on the water surface from one point or are soaked in sawdust and sowed. Drip cans are not satisfactory, as the valve or opening tends to "freeze" as the result of DDT precipitating out at the opening. (Note: Heavy doses will kill fish and other aquatic life. Concentrations in excess of one part in 10 million are lethal to fish. Excessive dosage on water or vegetation may be harmful to domestic animals.)

2. The emulsion may be used; it is not blown off the water surface by wind to the same extent as is oil. The emulsion is not

recommended for larviciding, however, as it should be conserved for use as a residual spray and in uses not well suited to the employment of oil.

3. Dusts. It is difficult to spread evenly one pound of 10 percent dust over an area of one acre (0.1 pound of DDT). For that reason it should be thoroughly mixed with 5 to 10 parts of fine road dust, condemned flour or any other inert diluent which is easily dispersed, and distributed at the prescribed rate. In critical areas larger doses up to 0.5 pound or more per acre may be required.
(Note: Due to the large size of the particles of commercial concentrated DDT, it cannot be effectively mixed with diluent dusts in the field. It is necessary, therefore, to use the 10 percent dust as the basic material for mixture with additional inert material.)

C. Against flies. The potentialities of DDT against flies was first fully realized through an accident which occurred at a testing laboratory. DDT was being mixed with dust, and nearly all of the flies in a large experimental cage several hundred feet from the mixer were killed.

1. Emulsions and oil or kerosene solutions, when sprayed in a fine form, will kill flies very efficiently. About 30 to 45 minutes may be required before flies show signs of being affected; lethal action is certain, though it may be somewhat delayed. Repeated or single heavy spraying imparts residual action to the exposed surfaces.

2. Dusts are very effective in killing flies. Relatively light dusting about heads, garbage racks, etc., is recommended. A pound of DDT (in dust) was dispersed as a roachicide in a store. Following this single application the owner did not find it necessary to spray against flies for two weeks. Previously standard fly spray was required several times daily.

3. Residual action is particularly important. DDT should be applied to surfaces on which flies are prone to alight: heads (latrines), ceilings, light cords, screening, garbage racks, etc. Two to four cubic centimeters of 5 percent solution per square foot (one quart to 250 to 500 square feet) are adequate for prolonged effect. A single spraying of a 1 percent solution rendered a barn (previously heavily infested) practically free of flies for 36 days.

D. Bedbugs. Sanitation officers need no longer live in dread of bedbugs. When properly applied, DDT will keep mattresses free of bedbugs for 6 months or more.

1. The 5 percent kerosene spray is recommended. Using about 250 cc. per bed (including mattress, pillow, springs and bedframe),

all bedbugs have been killed. Bugs experimentally reintroduced 4 to 6 months later were killed. Three and one-half gallons of 5 percent solution is adequate for a 70-man barracks. The recommended technic for barracks or ships is as follows:

(a) All clothing, rubber material (as gas masks), and other objects to be protected from kerosene, are covered or removed from the barracks.

(b) Workers should wear filter-type masks or moistened fine-gauze mask over the nose and mouth. Most of the windows or ports should be closed so that droplets will fall on exposed walls and other surfaces, imparting residual effect.

(c) Mattresses should be placed in piles of 8 to 10 each. Bunks (if movable) should be stood on end along the walls so that excess spray will fall on walls.

(d) A fine spray is best, but too fine a spray (fog-like) is wasteful and ineffective. A powered paint sprayer gives the best results; adjustment of the nozzle to a "brush-shaped" spray is best.

(e) First spray the outside surfaces of the pile of mattresses. Then the man operating the sprayer applies the solution to one side of the top mattress; his assistant quickly turns it over to be treated on the other side, then moves it away while the sprayer begins on the second mattress. A slight moistening of the surface is all that is required; a few minutes after spraying, the kerosene will have partly evaporated, leaving visible small glistening DDT crystals adherent to the surface. Pillows are treated in a similar manner.

(f) A rapid spraying of springs and bed frames is then done, directing the spray toward walls and bulkheads in order that excess material may be deposited on them. If this is done direct spraying of these surfaces is not necessary.

(g) Personnel will tend to use excessive amounts; a trial run on a few mattresses will serve as an indication as to whether the right amounts are being used.

(h) Smoking in room should be prohibited until the following morning.

(i) Shortly after spraying is completed all sizable droplets will have adhered to the wall or floor surfaces, and all the windows should be opened. The mattresses

should then be returned to the beds; they may be slept on after they have been aired for four hours.
When the above technic is followed, all bedbugs on the bed as a rule will be killed within 24 hours. Bugs introduced up to 6 months later will be killed. It is unnecessary to treat the walls, cracks, etc. specially, as the insects will obtain a lethal dose when they go from their habitat in the wall, or other place, to the bed for a blood meal. It may be necessary to spray blankets and the inside of barracks bags; the canvas of cots should be treated. When furniture or other upholstered material is treated for bedbugs, the emulsion is recommended due to the fact that it leaves no oil stain.

E. Against Lice. DDT has made possible the effectual control of louse-borne typhus. Navy experience with this disease has been limited. The Army has had extensive experience in louse control in North Africa and Italy, upon which the following recommendations are based:

1. Insecticide Powder for Body Lice (a two-ounce can).
This powder is a mixture of 10 percent DDT in an inert diluent ready for use from the 2-ounce sifter-top can. It is applied to the entire inner surface of clothing worn next to the skin, giving special attention to the seams. The seams of the outer garments are also dusted. The treated clothing is rubbed lightly to spread the powder. One to two ounces per man are required; application must be repeated after one month (if clothing is unwashed) or after each change of clothing.
The 10 percent DDT in talc or pyrophyllite which is supplied in bulk may be used in the delousing of large groups of individuals. The use of hand or power dusters equipped with a 6 to 8 inch extension tube at the outlet saves time, and may be employed as follows: The powder must be distributed on the inside surfaces of the inner garments and on the skin itself. Areas about the neck, armpits, waist, shirt tail, and crotch should receive special attention. Extra clothing and bedding should likewise be treated in order not to neglect an important reservoir of lice. Such mechanical application requires about one and one-half ounces of powder per individual.

2. Impregnation of underwear with DDT emulsion is effective in killing lice even after 6 to 8 weekly washings with soap and and water. The recommended amount of DDT is 2 percent of the weight of the underwear. This dosage may be obtained by dipping the underwear in a 2 percent emulsion (prepared by adding one gallon of emulsion concentrate to eleven gallons of water), and wringing moderately dry. The Lyster bag (which should not be used for drinking water subsequent to this employment) is well suited for the dipping, its 30 gallon capacity being adequate for 125 suits of two-piece (50 percent wool) underwear. The emulsion does not affect the rubber lining of this bag or

the rubber rollers of a wringer. Tongs, or other means of dipping the under wear, should be used rather than the bare hands if one operator is to do all the dipping.

F. Crab Lice may be effectively controlled by applying the 10 percent powder to the hairy regions of the body (except the head). The individual should not bathe for 24 hours. As eggs are not destroyed by DDT, the treatment must be repeated after 8 to 14 days in order to kill the new crop before they have reached the egg-laying stage.

G. Against Fleas.

1. 10 percent DDT in talc or pyrophyllite is recommended for application to animals having fleas. The material should be rubbed into the fur. Oily solutions are contraindicated, since in this form DDT is absorbed in toxic doses. In plague control, the dust should be blown into spaces infested with fleas or rats. It will kill fleas leaving the carcasses of rats which have succumbed to the disease; if fairly heavy doses are used, rats will obtain lethal dosage through licking the DDT from their paws.

2. 5 percent DDT in kerosene, oil, or emulsion will kill fleas. The application for residual action is effective, and is recommended.

H. Against Roaches. The German roach (light brown, one-half inch long roach, common to southern U.S.) is more difficult to kill with DDT than most insects. Other roaches, however, are relatively easy to kill.

1. 5 percent DDT in kerosene, oil or emulsion kills roaches by residual action more effectively than will DDT dust. The material should be sprayed around pipes, on table legs, in cracks, and other areas frequented by roaches.

2. 10 percent DDT in talc (as supplied in bulk) should not be diluted, as the 10 percent strength is required against roaches. It should be generously applied to cracks and other points inhabited by or traversed by roaches.

I. Mites (chiggers). The delayed action of DDT makes the 10 percent powder ineffectual as a preventive against Tsutsugamushi Fever (scrub typhus). Repellents such as dimethylphthalate are more efficient for killing mites.

J. Spiders, Ticks, Centipedes. DDT may not be depended upon to kill these insects.

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The recommendations contained in this manual are based upon almost two years work by the Department of Agriculture, supported whenever possible by the field experience in which service equipment was used. Personnel employing DDT in the manner recommended are requested to advise the Bureau of Medicine and Surgery as to the effectiveness of the agent, the difficulties encountered in the field, and any other pertinent observations which may be of value in developing the most effective use of this new insecticide.

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